(21%) 1. Choose the number (a,b,c,d or e) of the correct answer for the following problems. Note that this is a "single choice". However, do not try to make the choice blindly. You get "+3" points when the answer is right, while "-2" points will be given to each wrong answer. Please write down the answer package on the answer sheet in the form such as

1. (1) a
   (2) c
   (3) c
   (4) d
   (5) e
   (6) b
   (7) c

(1) In a "A-B" binary melt, a solute species "B" of which the self-interaction coefficient $e_B^{(B)}$ is positive displays
a. positive deviation from Henry's Law
b. positive deviation from Raoult's Law
c. regative deviation from Henry's Law
d. ideal behavior
e. none of above

(2) Oxygen saturated iron has
a. $a_{FeO} = 1$ (pure liquid FeO standard state)
b. $a_{O_2} = 1$ (1 atm ideal gas standard state)
c. $a_O = 1$ (pure liquid O standard state)
d. $h_O = 1$ (1 wt% H.L. solution standard state)
e. none of above

(3) The solubility of nitrogen at 1 atm pressure in liquid iron increases as the temperature is increased. Dissolution of nitrogen in iron
a. is endothermic
b. is exothermic
c. gives an ideal solution
d. it depends

(4) For a CO/CO_2 gas phase equilibrated with graphite, as the system pressure is increased at constant temperature, the mole fraction ratio N_{CO}/N_{CO_2}
a. decreases
b. increases
c. remains the same
d. it depends

(5) The molar volume of a liquid metal is greater than that of the solid metal. An increase in pressure causes the equilibrium melting temperature to
a. decrease
b. increase
c. remain the same
d. it depends

(6) given date for an element Z [heat capacity $C_p = 24+5\times10^{-3}\ T$ J/°k mole]
thermal expansion coefficient = 4×10^{-5}/°k
density = 20 g/cm^3, molecular weight = 200 g/mole
Start with Z in the state T=298°k, p=1atm
To what temperature would you have to heat Z at constant pressure to raise its molar enthalpy by 1 J?
a. 286.4°k
b. 298.04 °k
c. 541.32 °k
d. 785.44 °k
e. >1000 °k

(7) What pressure would you have to apply to Z at constant temperature to increase its molar enthalpy by 1 J
a. 1 atm
b. 1.98 atm
c. 273 atm
d. >1000 atm
e. 0.174 atm

2. An ideal gas is compressed from the initial state (P_1,V_1) to the final state (P_2,V_2) either isothermally or adiabatically. Assume $V_1 = 8\ V_2$
1) Plot the isothermal and adiabatical process in the P-V diagram, also indicate P_1,V_1,P_2,V_2 (5%)
2) For the magnitude of the work done on an ideal gas to be compressed from V_1 to V_2, which is larger?
   a. Explain your answer graphically from the diagram (4%)
   b. Justify your answer analytically by evaluating the numerical number of the work done isothermally, $|W_T|$, and adiabatically, $|W_s|$, in term of the gas constant R and temperature in the initial state T_1. (10%), (ln2 = 0.693)
   Note that your answer should be in the form of $|Ws| = aRT_1$,
   $|W_T| = b\ RT_1$, where a, and b is evaluated constant.

3. (10%) For a reaction system containing a gas mixture with 75% CO and 25% CO_2 at a total pressure of P_T= 4 atm. What is the temperature range when the carbon sooting occurs.
Given

$$C(s) + 1/2O_2(g) \rightarrow CO(g) \quad \Delta G^0 = -28{,}200-20.16T$$
$$C(s) + O_2(g) \rightarrow CO_2(g) \quad \Delta G^0 = -94{,}775+0.02T$$

(ΔG^0: cal/mole)
(ln3 = 1.0986)
Note that a final numerical data is required.

4. Calculate the value of $\left(\partial U/\partial P\right)_T$ for one mole of ideal gas at T=300 K. (10%)

5. (a) Write down the van der Waals gas equation. (2%)
(b) Explain the physical meanings involved in the correction terms, and how they are modified from the ideal gas equation. (8%)
(c) Calculate the value of heat of evaporation, ΔH_v, when the temperature approaches the critical temperature, $T \rightarrow T_{cr}$. (10%)

6. The Gibbs free energy change of a binary solution is $\Delta G_m=(1+2X_1+RT)(X_1 \ell nX_1+X_2 \ell nX_2)$, where X_1 and X_2 are the mole fraction of component 1 and 2, respectively. Is this system a regular solution ? Prove your answer. (10%)

7. (a) Explain the "principle of equipartition of energy". (5%)
(b) At ordinary temperatures and pressures the heat capacity (C_p) of ammonia gas is 37 J/mol-K. List all the independent components of motion that the molecule can display. Explain how do you obtain this result. (Gas constant is 8.314 J/mol-K) (5%)